4.2 Surface Water and Sediment Surveillance

G. W. Patton

Surface water and sediment on and near the Hanford Site are monitored to determine the potential impacts of Hanford-originated radiological and chemical contaminants to the public and to the aquatic environment. Surface-water bodies included in routine surveillance are the Columbia River, riverbank springs, onsite ponds, and irrigation water at the Riverview irrigation canal. Sediment surveillance is conducted for the Columbia River and riverbank springs. Tables 4.2.1 and 4.2.2 summarize the sampling locations, types, frequencies, and analyses included in surface-water and sediment surveillance activities during 1997. Sample locations are identified in Figure 4.2.1. This section describes the surveillance effort and summarizes the results for these aquatic environments. Detailed analytical results are reported in PNNL-11796.

4.2.1 Columbia River Water

The Columbia River is the second largest river in the continental United States in terms of total flow and is the dominant surface-water body on the Hanford Site. The original selection of the Hanford Site for plutonium production and processing was based, in part, on the abundant water supply offered by the river. The river flows through the northern edge of the site and forms part of the site's eastern boundary. The river is used as a source of drinking water for onsite facilities and communities located downstream from the Hanford Site. Water from the river downstream of the site is also used extensively for crop irrigation. In addition, the Hanford Reach of the Columbia River is used for a variety of recreational activities, including hunting, fishing, boating, water-skiing, and swimming.

Originating in the mountains of eastern British Columbia, the Columbia River drains a total area of approximately 670,000 km^2 (260,000 mi^2) en route to the Pacific Ocean. The flow of the river is regulated by 3 dams in Canada and 11 dams in the United States, 7 upstream and 4 downstream of the site. Priest Rapids Dam is the nearest upstream dam and McNary Dam is the nearest downstream dam from the site. The Hanford Reach of the Columbia River extends from Priest Rapids Dam to the head of Lake Wallula (created by McNary Dam) near Richland, Washington. The Hanford Reach is the last stretch of the Columbia River in the United States above Bonneville Dam that remains unimpounded.

Flows through the Hanford Reach fluctuate significantly and are controlled primarily by operations at Priest Rapids Dam. Annual average flows of the Columbia River below Priest Rapids Dam are nearly 3,400 m^3/s (120,000 ft^3/s) (WA-94-1). In 1997, the Columbia River had exceptionally high flow; the average daily flow rate below Priest Rapids Dam was 4,790 m^3/s (169,000 ft^3/s). The peak monthly average flow rate occurred during June (9,150 m^3/s [323,000 ft^3/s]) (Figure 4.2.2). The lowest monthly average flow rate occurred during November (2,970 m^3/s [105,000 ft^3/s]). Daily flow rates varied from 1,870 to 11,600 m^3/s (66,200 to 410,000 ft^3/s) during 1997. As a result of fluctuations in discharges, the depth of the river varies significantly over time. River stage may change along the Hanford Reach by up to 3 m (10 ft) within a few hours (Section 3.3.7 in PNL-10698). Seasonal changes of approximately the same magnitude are also observed. River-stage fluctuations measured at the 300 Area are approximately half the magnitude of those measured near the 100 Areas because of the effect of the pool behind McNary Dam (PNL-8580) and the relative distance of each area from Priest Rapids Dam. The width of the river varies from approximately 300 to 1,000 m (980 to 3,300 ft) along the Hanford Site.

Pollutants, both radiological and nonradiological, are known to enter the Columbia River along the Hanford Reach. In addition to permitted direct discharges of liquid effluents from Hanford facilities, contaminants in groundwater from past discharges to the ground are known to seep into the river (DOE/RL-92-12, PNL-5289, PNL-7500, WHC-SD-EN-TI-006). Effluents from each direct discharge point are routinely monitored and reported by the responsible operating contractor; these were summarized in Section 3.1, "Facility Effluent Monitoring." Direct discharges are identified and regulated for

Table 4.2.1. Surface-Water Surveillance, 1997

Location	Sample Type	Frequency[a]	Analyses
Columbia River - Radiological			
Priest Rapids Dam and Richland Pumphouse	Cumulative	M Comp[b]	Alpha, beta, lo ^{3}H,[c] gamma scan, ^{90}Sr, ^{99}Tc, U[d]
	Particulate (filter)	Q Cont [e]	Gamma scan, Pu[f]
	Soluble (resin)	Q Cont	Gamma scan, ^{129}I, Pu
Vernita Bridge and Richland Pumphouse	Grab (transects)	Q	lo ^{3}H, ^{90}Sr, U
100-F, 100-N, 300, and old Hanford Townsite	Grab (transects)	A	lo ^{3}H, ^{90}Sr, U
Columbia River - Nonradiological			
Vernita and Richland Pumphouse[g]	Grab	Q	NASQAN, temperature, dissolved oxygen, turbidity, pH, alkalinity, anions, suspended solids, dissolved solids, specific conductance, hardness (as $CaCO_3$), Ca, P, Cr, Mg, N-Kjeldahl, Fe, NH_3, $NO_3 + NO_2$
	Grab (transects)	Q	ICP[h] metals, anions
	Grab (transects)	A	Cyanide (CN^-)
100-F, 100-N, 300, and old Hanford Townsite	Grab (transects)	A	ICP metals, anions
Onsite Ponds			
West Lake	Grab	Q	Alpha, beta, ^{3}H, ^{90}Sr, ^{99}Tc, U, gamma scan
B Pond (216-B-3C)		Grab	Q Alpha, beta, ^{3}H, ^{90}Sr, gamma scan
Fast Flux Test Facility Pond	Grab	Q	Alpha, beta, ^{3}H, gamma scan
Offsite Water			
Riverview irrigation canal	Grab	3[i]	Alpha, beta, ^{3}H, ^{90}Sr, U, gamma scan
Riverbank Springs			
100-H Area	Grab	A	Alpha, beta, ^{3}H, ^{90}Sr, ^{99}Tc, U, gamma scan, ICP metals, anions
100-B Area	Grab	A	Alpha, beta, ^{3}H, ^{90}Sr, ^{99}Tc, gamma scan, ICP metals, anions
100-D, 100-K, and 100-N Areas	Grab	A	Alpha, beta, ^{3}H, ^{90}Sr, gamma scan, ICP metals, anions
Old Hanford Townsite and 300 Area	Grab	A	Alpha, beta, ^{3}H, ^{129}I, ^{90}Sr, ^{99}Tc, U, gamma scan, ICP metals, anions

(a) A = annually; M = monthly; Q = quarterly; Comp = composite.
(b) M Comp indicates river water was collected hourly and composited monthly for analysis.
(c) lo ^{3}H = low-level tritium analysis (10-pCi/L detection limit), which includes an electrolytic preconcentration.
(d) U = isotopic uranium-234,235,238.
(e) Q Cont = river water was sampled for 2 weeks by continuous flow through a filter and resin column and multiple samples were composited quarterly for analysis.
(f) Pu = isotopic plutonium-238 and -239,240.
(g) Numerous water quality analyses are performed by the U.S. Geological Survey in conjunction with the National Stream Quality Accounting Network (NASQAN) Program.
(h) ICP = inductively coupled plasma analysis method.
(i) Three samples during irrigation season.

Table 4.2.2. Sediment Surveillance, 1997

Location[(a)]	Frequency	Analyses
River		All river sediment analyses included gamma scan, ^{90}Sr, U, Pu, ICP metals, SEM/AVS[(f)]
Priest Rapids Dam: Grant County shore 1/3 from Grant County shore 2/3 from Grant County shore Yakima County shore	A	
White Bluffs Slough	A	
100-F Slough	A	
Hanford Slough	A	
Richland	A	
McNary Dam: Oregon shore 1/3 from Oregon shore 2/3 from Oregon shore Washington shore	A[(b)]	
Springs		All springs sediment analyses included gamma scan, ^{90}Sr, U, ICP metals
100-B Area	A	
100-K Area	A	
100-N Area Spring 8-13	A	
100-F Area	A	
Old Hanford Townsite Springs	A	
300 Area Spring 42-2	A	

(a) See Figure 4.2.1.
(b) A = annually.
(c) U = uranium-235 and -238 analyzed by low-energy photon analysis.
(d) Pu = isotopic plutonium-238 and -239,240.
(e) ICP = inductively coupled plasma analysis method.
(f) SEM/AVS = simultaneously extracted metals and acid volatile sulfide.

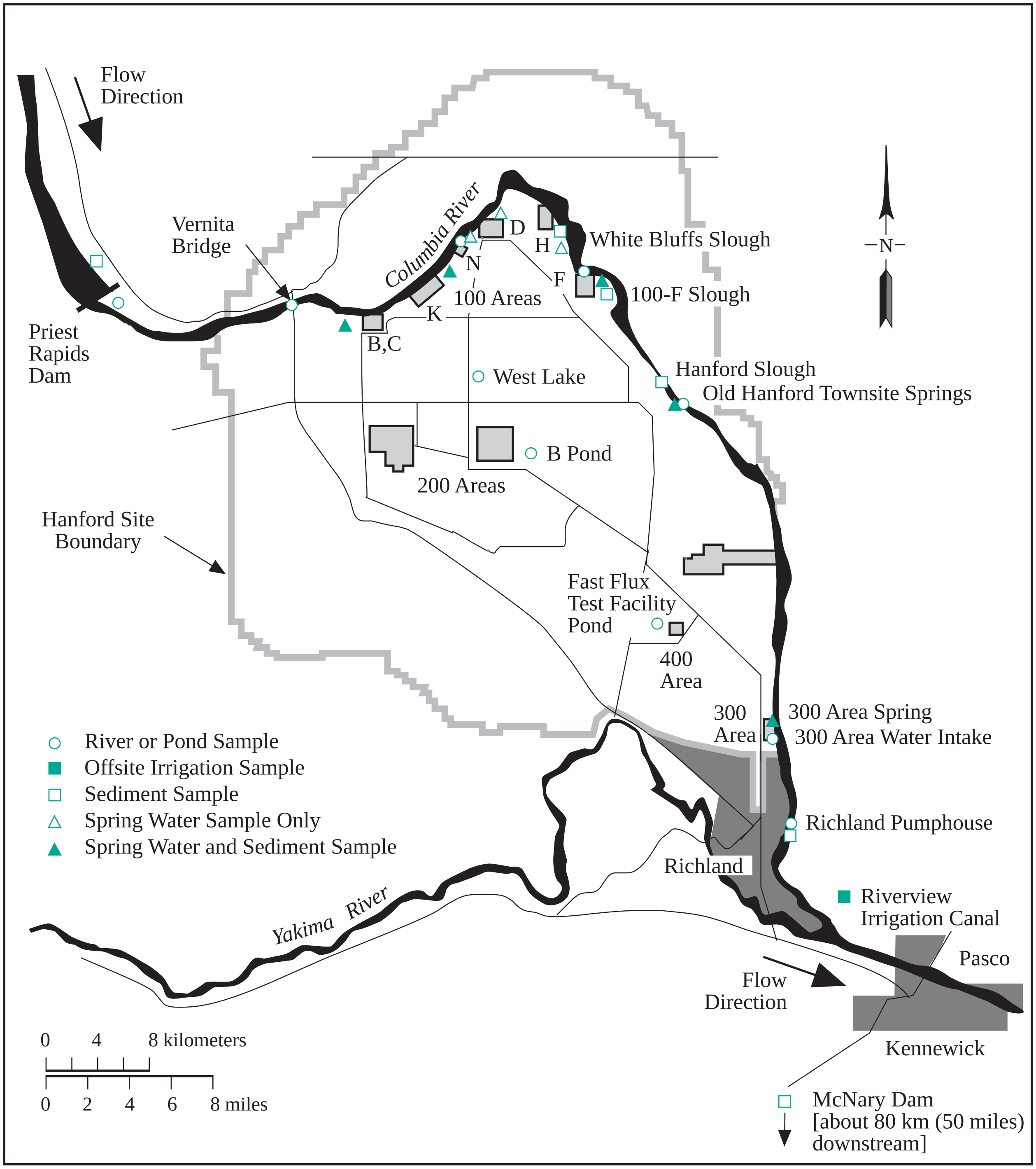

Figure 4.2.1. Water and Sediment Sampling Locations, 1997

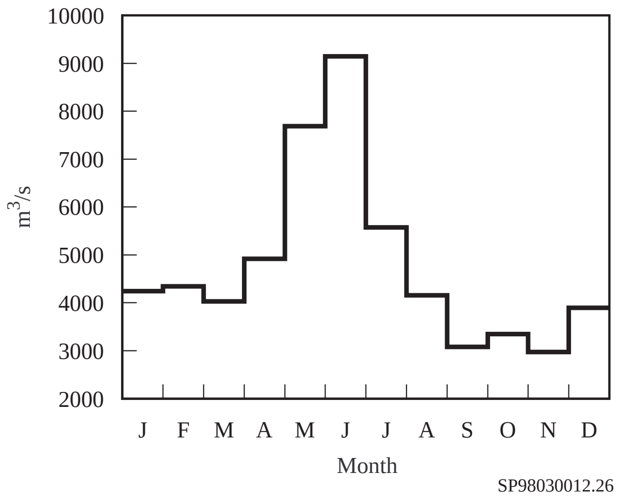

Figure 4.2.2. Mean Monthly Columbia River Flow Rates, 1997

nonradiological constituents under the National Pollutant Discharge Elimination System in compliance with the Clean Water Act. The National Pollutant Discharge Elimination System-permitted discharges at the Hanford Site were summarized in Section 2.2, "Compliance Status."

Washington State has classified the stretch of the Columbia River from Grand Coulee Dam to the Washington-Oregon border, which includes the Hanford Reach, as Class A, Excellent (Washington Administrative Code [WAC] 173-201A). Water quality criteria and water use guidelines have been established in conjunction with this designation and are provided in Appendix C (Table C.1).

4.2.1.1 Collection of River Water Samples and Analytes of Interest

Samples of Columbia River water were collected throughout 1997 at the locations shown in Figure 4.2.1. Samples were collected from fixed-location monitoring stations at Priest Rapids Dam and the Richland Pumphouse and from Columbia River transects established near the Vernita Bridge, 100-F Area, 100-N Area, Old Hanford Townsite, 300 Area, and Richland Pumphouse. Samples were collected upstream from Hanford Site facilities at Priest Rapids Dam and Vernita Bridge to provide background data from locations unaffected by site operations. Samples were collected from all other locations to identify any increase in contaminant concentrations attributable to Hanford operations. The Richland Pumphouse is the first downstream point of Columbia River water withdrawal for a municipal drinking water supply.

The fixed-location monitoring stations at Priest Rapids Dam and the Richland Pumphouse consisted of both an automated sampler and a continuous flow system. Using the automated sampler, unfiltered samples of Columbia River water (cumulative samples) were collected hourly and composited monthly for radiological analyses (see Table 4.2.1). Using the continuous flow system, particulate and soluble fractions of selected Columbia River water constituents were collected by passing water through a filter and then through a resin column. Filter and resin samples were exchanged approximately every 14 days and were combined into quarterly composite samples for radiological analyses. The river sampling locations and the methods used for sample collection are discussed in detail in DOE/RL-91-50, Rev. 2.

Analytes of interest in water samples collected from Priest Rapids Dam and the Richland Pumphouse included gross alpha, gross beta, selected gamma emitters, tritium, strontium-90, technetium-99, iodine-129, uranium-234, 235,238, plutonium-238, and plutonium-239,240. Gross alpha and beta measurements are indicators of the general radiological quality of the river and provide an early indication of change. Gamma scans provide the ability to detect numerous specific radionuclides (see Appendix E). Sensitive radiochemical analyses were used to determine the concentrations of tritium, strontium-90, technetium-99, iodine-129, uranium-234,235,238, plutonium-238, and plutonium-239,240 in river water during the year. Radionuclides of interest were selected for analysis based on their presence in effluents discharged from site facilities or in near-shore groundwater underlying the Hanford Site and for their importance in determining water quality, verifying effluent control and monitoring systems, and determining compliance with applicable standards. Analytical detection levels for all radionuclides were less than 10% of their respective ambient water quality criteria levels (see Appendix C, Table C.2).

Transect sampling was initiated as a result of findings of a special study conducted during 1987 and 1988 (PNL-8531). That study concluded that, under certain flow conditions, contaminants entering the river from the Hanford Site are not completely mixed at routine monitoring stations. Incomplete mixing results in a slight conservative bias in the data generated using the routine single-point sampling system at the Richland Pumphouse. The Vernita Bridge and the Richland Pumphouse transects were sampled quarterly during 1997. Annual transect sampling was conducted at the 100-F Area, 100-N Area, Old Hanford Townsite, and 300 Area locations.

Columbia River transect water samples collected in 1997 were analyzed for both radiological and chemical contaminants (see Table 4.2.1). Metals and anions (listed in DOE/RL-93-94, Rev. 1), were selected for analysis, following reviews of existing surface-water and groundwater data, various remedial investigation/feasibility study work plans, and preliminary Hanford Site risk assessments (DOE/RL-92-67, PNL-8073, PNL-8654, PNL-10400, PNL-10535). All radiological and chemical analyses of transect samples were performed on unfiltered water.

In addition to Columbia River monitoring conducted by Pacific Northwest National Laboratory in 1997, nonradiological water quality monitoring was also performed by the U.S. Geological Survey in conjunction with the National Stream Quality Accounting Network program. U.S. Geological Survey samples were collected along Columbia River transects quarterly at the Vernita Bridge and the Richland Pumphouse (Appendix A, Table A.4). Sample analyses were performed at the U.S. Geological Survey laboratory in Denver, Colorado for numerous physical and chemical constituents.

4.2.1.2 Radiological Results for Columbia River Water Samples

Fixed Location Sampling. Results of the radiological analyses of Columbia River water samples collected at Priest Rapids Dam and Richland Pumphouse during 1997 are reported in PNNL-11796 and summarized in Appendix A (Tables A.1 and A.2). These tables also list the maximum and mean concentrations of select radionuclides observed in Columbia River water in 1997 and during the previous 5 years. All radiological contaminant concentrations measured in Columbia River water in 1997 were less than DOE derived concentration guides (DOE Order 5400.5) and Washington State ambient surface-water quality criteria (WAC 173-201A and 246-290) levels (see Appendix C, Tables C.5 and C.2, respectively). Significant results are discussed and illustrated below, and comparisons to previous years are provided.

Concentrations of radionuclides monitored in Columbia River water were extremely low throughout the year. Radionuclides consistently detected in river water during 1997 included tritium, strontium-90, iodine-129, uranium-234,238, and plutonium-239,240. The concentrations of all other measured radionuclides were below detection limits in over 75% of samples collected. Tritium, strontium-90, iodine-129, and plutonium-239,240 exist in worldwide fallout, as well as in effluents from Hanford facilities. Tritium and uranium occur naturally in the environment, in addition to being present in Hanford Site effluents.

Figures 4.2.3 and 4.2.4 illustrate the average annual gross alpha and gross beta concentrations, respectively, at Priest Rapids Dam and Richland Pumphouse during the past 6 years. The 1997 average gross alpha and gross beta concentrations were similar to those observed during recent years. Monthly concentrations measured at the Richland Pumphouse in 1997 were not statistically different (unless otherwise noted in this section, the statistical test for difference are paired sample comparison and two-tailed t-test, 5% significance level) from those measured at Priest Rapids Dam. The average concentrations in Columbia River water at Priest Rapids Dam and Richland Pumphouse in 1997 were less than 5% of their respective ambient surface-water quality criteria levels of 15 and 50 pCi/L, respectively (WAC 246-290).

Figure 4.2.5 compares the annual average tritium concentrations at Priest Rapids Dam and Richland Pumphouse from 1992 through 1997. The general decline in tritium concentrations in river water remains evident at both locations. Statistical analysis indicated that monthly tritium concentrations in river water at the Richland Pumphouse were higher than those at Priest Rapids Dam.

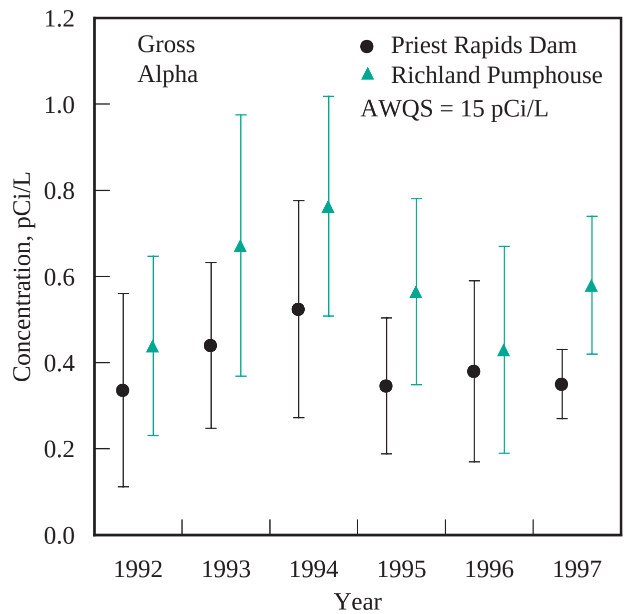

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Figure 4.2.3. Annual Average Gross Alpha Concentrations (±2 standard error of the mean) in Columbia River Water, 1992 Through 1997 (AWQS = ambient water quality standard)

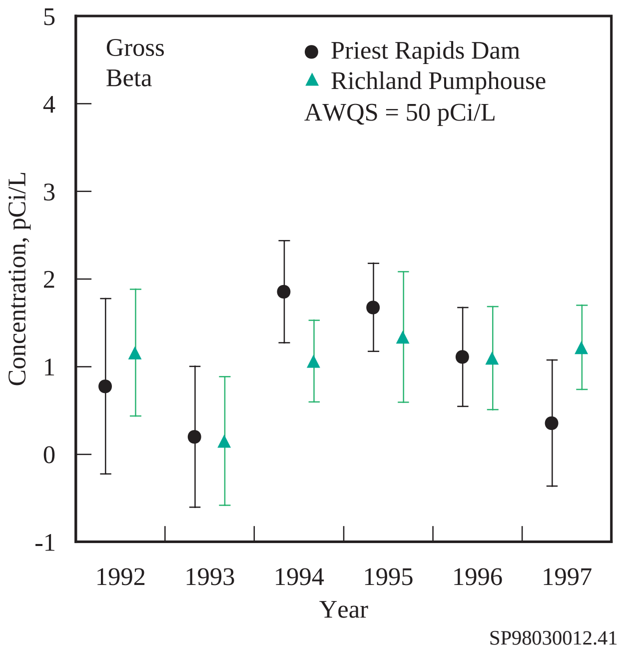

Figure 4.2.4. Annual Average Gross Beta Concentrations (±2 standard error of the mean) in Columbia River Water, 1992 Through 1997 (AWQS = ambient water quality standard)

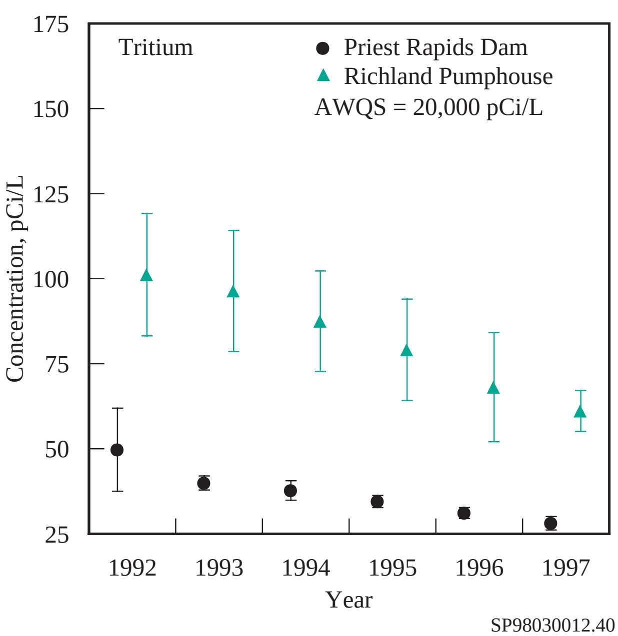

Figure 4.2.5. Annual Average Tritium Concentrations (±2 standard error of the mean) in Columbia River Water, 1992 Through 1997 (AWQS = ambient water quality standard)

However, 1997 average tritium concentrations in Columbia River water collected at the Richland Pumphouse were only 0.31% of the ambient surface-water quality criteria level of 20,000 pCi/L (WAC 246-290). Onsite sources of tritium entering the river include groundwater seepage and direct discharge from outfalls located in the 100 Areas (see Section 3.1, "Facility Effluent Monitoring," and Section 6.1, "Hanford Groundwater Monitoring Project"). Tritium concentrations measured at the Richland Pumphouse, while representative of river water used by the city of Richland for drinking water, tend to overestimate the average concentrations of tritium in the river at this location (PNL-8531). This bias is attributable to the contaminated 200 Areas' groundwater plume entering the river along the portion of shoreline extending from the Old Hanford Townsite to below the 300 Area, which is relatively close to the Richland Pumphouse sample intake. This plume is not completely mixed within the river at the Richland Pumphouse. Sampling along a transect at the pumphouse during 1997 confirmed the existence of a concentration gradient in the river under certain flow conditions and is discussed subsequently in this section. The extent to which samples taken from the Richland Pumphouse overestimate the average tritium concentrations in the Columbia River at this location is highly variable and appears to be related to the flow rate of the river just before and during sample collection.

The annual average strontium-90 concentrations in Columbia River water collected from Priest Rapids Dam and Richland Pumphouse from 1992 through 1997 are presented in Figure 4.2.6. Concentrations observed in 1997 were similar to those observed previously. Groundwater plumes containing strontium-90 enter the Columbia River throughout the 100 Areas (Chapter 5.0 in PNL-10698). The highest strontium-90 concentrations in groundwater onsite that have been found are the result of past discharges to the 100-N Area liquid waste disposal facilities. Despite the Hanford Site source, the differences between monthly strontium-90 concentrations at Priest Rapids Dam and Richland Pumphouse in 1997 were not statistically different. Average strontium-90 concentrations in Columbia River water at the Richland Pumphouse were 1.0% of the 8-pCi/L ambient surface-water quality criteria level (WAC 246-290).

Annual average total uranium concentrations (i.e., the sum of uranium-234,235,238 concentrations) at Priest Rapids Dam and Richland Pumphouse for 1992 through 1997 are shown in Figure 4.2.7. The large error associated with

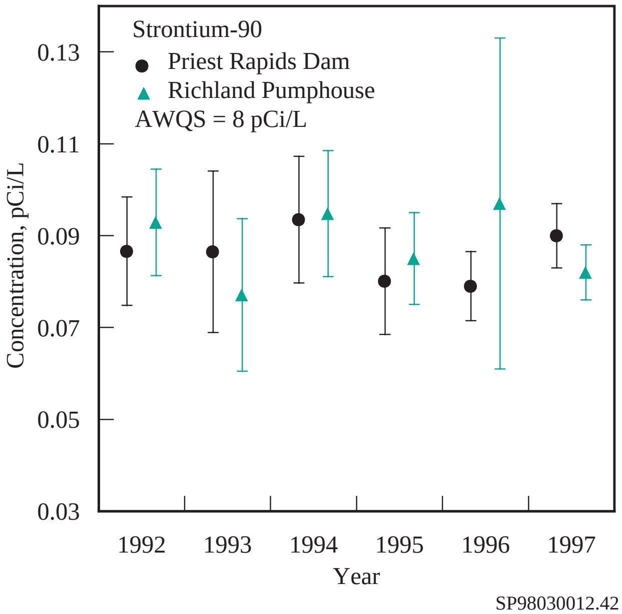

Figure 4.2.6. Annual Average Strontium-90 Concentrations (±2 standard error of the mean) in Columbia River Water, 1992 Through 1997 (AWQS = ambient water quality standard)

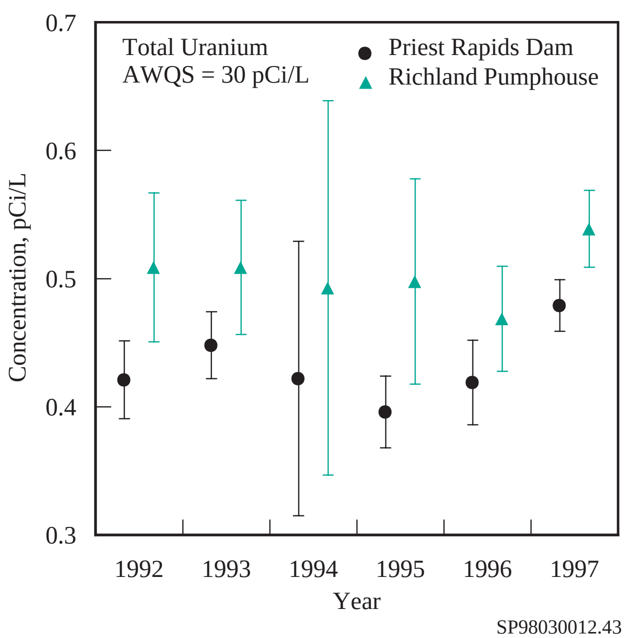

Figure 4.2.7. Annual Average Total Uranium Concentrations (±2 standard error of the mean) in Columbia River Water, 1992 Through 1997 (AWQS = ambient water quality standard)

1994 results was attributed to an unusually low concentration found in the December sample at each location. Total uranium concentrations observed in 1997 were similar to those observed during recent years. Monthly total uranium concentrations measured at the Richland Pumphouse in 1997 were statistically higher than those measured at Priest Rapids Dam. Although there is no direct discharge of uranium to the river, uranium is present in the groundwater beneath the 300 Area as a result of past Hanford operations (see Section 6.1, "Hanford Groundwater Monitoring Project") and has been detected at elevated levels in riverbank springs in this area (see Section 4.2.3, "Riverbank Springs Water"). Naturally occurring uranium is also known to enter the river across from the Hanford Site via irrigation return water and groundwater seepage associated with extensive irrigation north and east of the Columbia River (PNL-7500). There are currently no ambient surface-water quality criteria levels directly applicable to uranium. However, total uranium concentrations in the river during 1997 were well below the proposed U.S. Environmental Protection Agency (EPA) drinking water standard of 20 µg/L (30 pCi/L; EPA 822-R-96-001).

The annual average iodine-129 concentrations for Priest Rapids Dam and Richland Pumphouse for 1992 through 1997 are presented in Figure 4.2.8. Only one quarterly

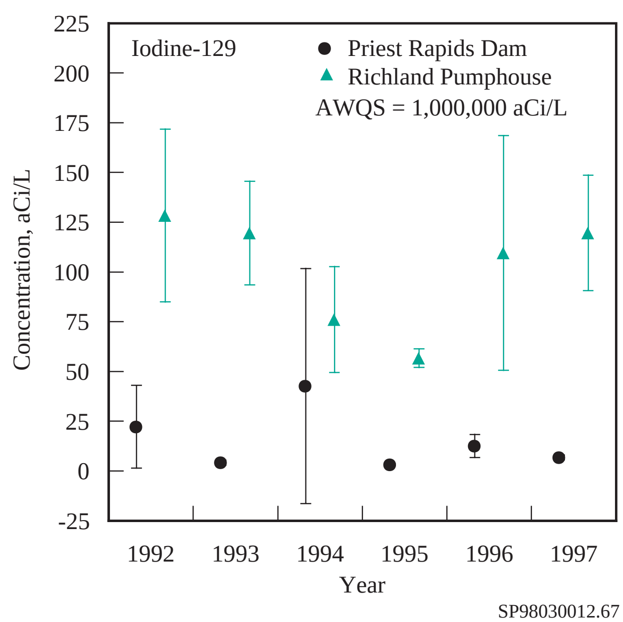

Figure 4.2.8. Annual Average Iodine-129 Concentrations (±2 standard error of the mean) in Columbia River Water, 1992 Through 1997 (AWQS = ambient water quality standard)

iodine-129 result was available for the Richland Pumphouse during 1995 because of construction activities at the structure. The average concentration of iodine-129 in Columbia River water at the Richland Pumphouse was extremely low during 1997 (0.011% of the ambient surface-water quality criteria level of 1 pCi/L [1,000,000 aCi/L] [WAC 246-290]) and similar to levels observed during recent years. The onsite source of iodine-129 to the Columbia River is the discharge of contaminated groundwater along the portion of shoreline downstream of the Old Hanford Townsite (see Section 6.1, "Hanford Groundwater Monitoring Project"). The iodine-129 plume originated in the 200 Areas from past waste disposal practices. Quarterly iodine-129 concentrations in Columbia River water at the Richland Pumphouse were statistically higher than those at Priest Rapids Dam.

During 1997, average plutonium-239,240 concentrations at Priest Rapids Dam and Richland Pumphouse were 79 ± 48 and 81 ± 48 aCi/L, respectively. For both locations, plutonium was detected only for the particulate fraction of the continuous water sample (i.e., detected on the filters but not detected on the resin column). No ambient surface-water quality criteria levels exist for plutonium-239,240. However, if the DOE derived concentration guides (DOE Order 5400.5; see Appendix C, Table C.5), which are based on a 100-mrem dose standard, are converted to the 4-mrem dose equivalent used to develop the drinking water standards and ambient surface-water quality criteria levels, 1,200,000 aCi/L would be the relevant guideline for plutonium-239,240. There was no statistical difference in concentrations at Priest Rapids Dam and Richland Pumphouse.

River Transect Sampling. Radiological results of samples collected along Columbia River transects established at the Vernita Bridge, 100-F Area, 100-N Area, Old Hanford Townsite, 300 Area, and Richland Pumphouse during 1997 are presented in Appendix A (Table A.3) and PNNL-11796. Constituents that were consistently detected at concentrations greater than two times their associated total propagated analytical uncertainty included tritium, strontium-90, uranium-234, and uranium-238. All measured concentrations of these radionuclides were less than applicable ambient surface-water quality criteria levels.

Tritium concentrations measured along Columbia River transects during August 1997 are depicted in Figure 4.2.9. The results are displayed such that the observer's view is upstream. Vernita Bridge is the most upstream transect. Stations 1 and 10 are located along the Benton County and Franklin/Grant Counties shorelines, respectively. The highest tritium concentrations observed in 1997 river transect water (see Figure 4.2.9) were detected along the shoreline of the Old Hanford Townsite, where groundwater containing tritium concentrations in excess of the ambient surface-water quality criteria level of 20,000 pCi/L is known to discharge to the river (Chapter 5.0 in PNL-10698). Slightly elevated levels of tritium were also evident near the Hanford Site shoreline at the 100-N Area, 300 Area , and Richland Pumphouse. The presence of a tritium concentration gradient in the Columbia River at the Richland Pumphouse supports previous conclusions made in HW-73672 and PNL-8531 that contaminants in the 200 Areas' groundwater plume entering the river at, and upstream of, the 300 Area are not completely mixed at the Richland Pumphouse. The gradient is most pronounced during periods of relatively low flow. As noted since transect sampling was initiated in 1987, the mean concentration of tritium measured along the Richland Pumphouse transect was less than that measured in monthly composited samples from the pumphouse, illustrating the conservative bias (i.e., overestimate) of the fixed-location monitoring station.

Strontium-90 concentrations in 1997 transect samples were fairly uniform across the width of the river and varied little between transects. The mean concentration of strontium-90 found during transect sampling at the Richland Pumphouse was similar to that measured in monthly composite samples from the pumphouse. The similarity indicates that strontium-90 concentrations in water collected from the fixed-location monitoring station are representative of the average strontium-90 concentration in the river at this location.

Total uranium concentrations in 1997 were elevated along the Franklin County shoreline of the 300 Area and Richland Pumphouse transects. The highest total uranium concentration was measured near the Franklin County shoreline of the 300 Area transect and likely resulted from groundwater seepage and water from irrigation return canals on the east side of the river that contained naturally occurring uranium (PNL-7500). The mean concentration of total uranium across the Richland Pumphouse transect was similar to that measured in monthly composited samples from the pumphouse.

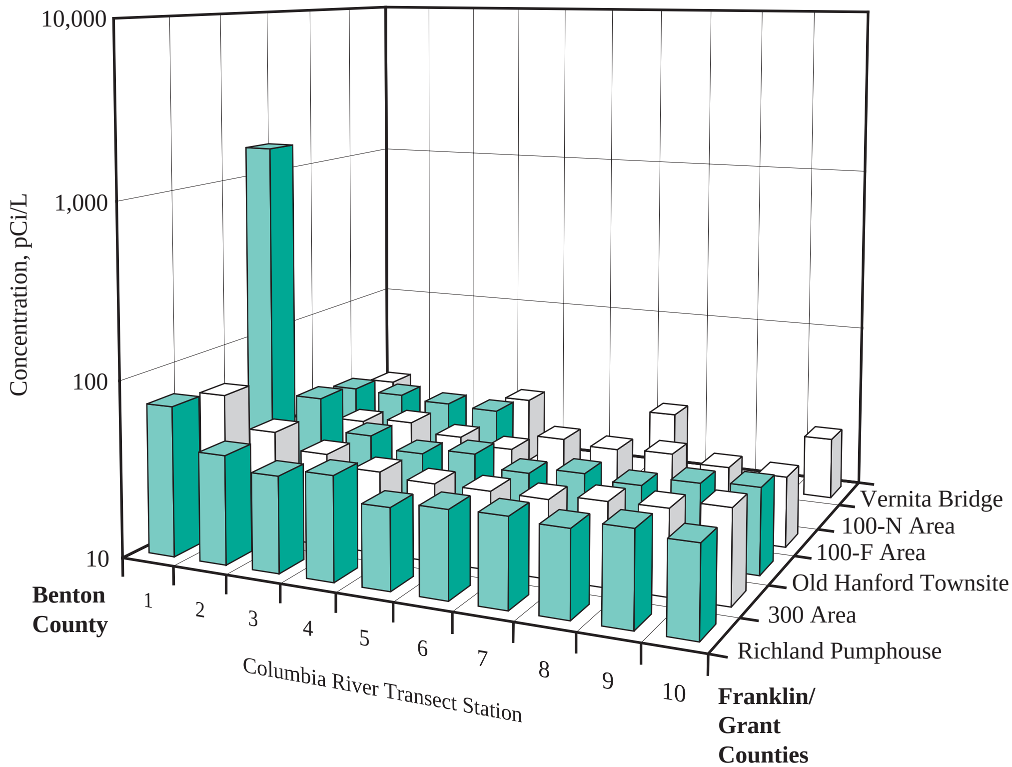

Figure 4.2.9. Tritium Concentrations in Water Samples from Columbia River Transects, August 1997

4.2.1.3 Nonradiological Results for Columbia River Water Samples

The Pacific Northwest National Laboratory and the U.S. Geological Survey compiled nonradiological water quality data during 1997. A number of the parameters measured have no regulatory limits; however, they are useful as indicators of water quality and contaminants of Hanford origin. Potential sources of pollutants not associated with Hanford include irrigation return water and groundwater seepage associated with extensive irrigation north and east of the Columbia River (PNL-7500).

U.S. Geological Survey. Figure 4.2.10 shows the Vernita Bridge and Richland Pumphouse U.S. Geological Survey results for 1992 through 1997 (1997 results are preliminary) for several water quality parameters with respect to their applicable standards. The complete list of preliminary results obtained through the U.S. Geological Survey National Stream Quality Accounting Network program is documented in PNNL-11796 and is summarized in Appendix A (Table A.4). Final results are published annually by the U.S. Geological Survey (e.g., Wiggins et al. 1996).

The 1997 U.S. Geological Survey results were comparable to those reported during the previous 5 years. Applicable standards for a Class A-designated surface-water body were met. During 1997, there was no indication of any deterioration of water quality resulting from site operations along the Hanford Reach of the Columbia River (see Appendix C, Table C.1).

River Transect Samples. Results of nonradiological sampling conducted by Pacific Northwest National Laboratory along transects of the Columbia River in 1997 at Vernita Bridge, 100-F Area, 100-N Area, Old Hanford Townsite, 300 Area, and Richland Pumphouse are provided in PNNL-11796. The concentrations of metals and anions observed in river water in 1997 were similar to those observed in the past. Several metals and anions were detected in Columbia River transect samples both upstream and downstream of the Hanford Site. Arsenic, antimony, cadmium, chromium, lead, nickel, thallium, and zinc were detected in the majority of samples, with similar levels at most locations. Beryllium, selenium, and silver were only occasionally detected. Nitrate concentrations were slightly elevated along the Benton County shoreline for the 300 Area and Old Hanford Townsite

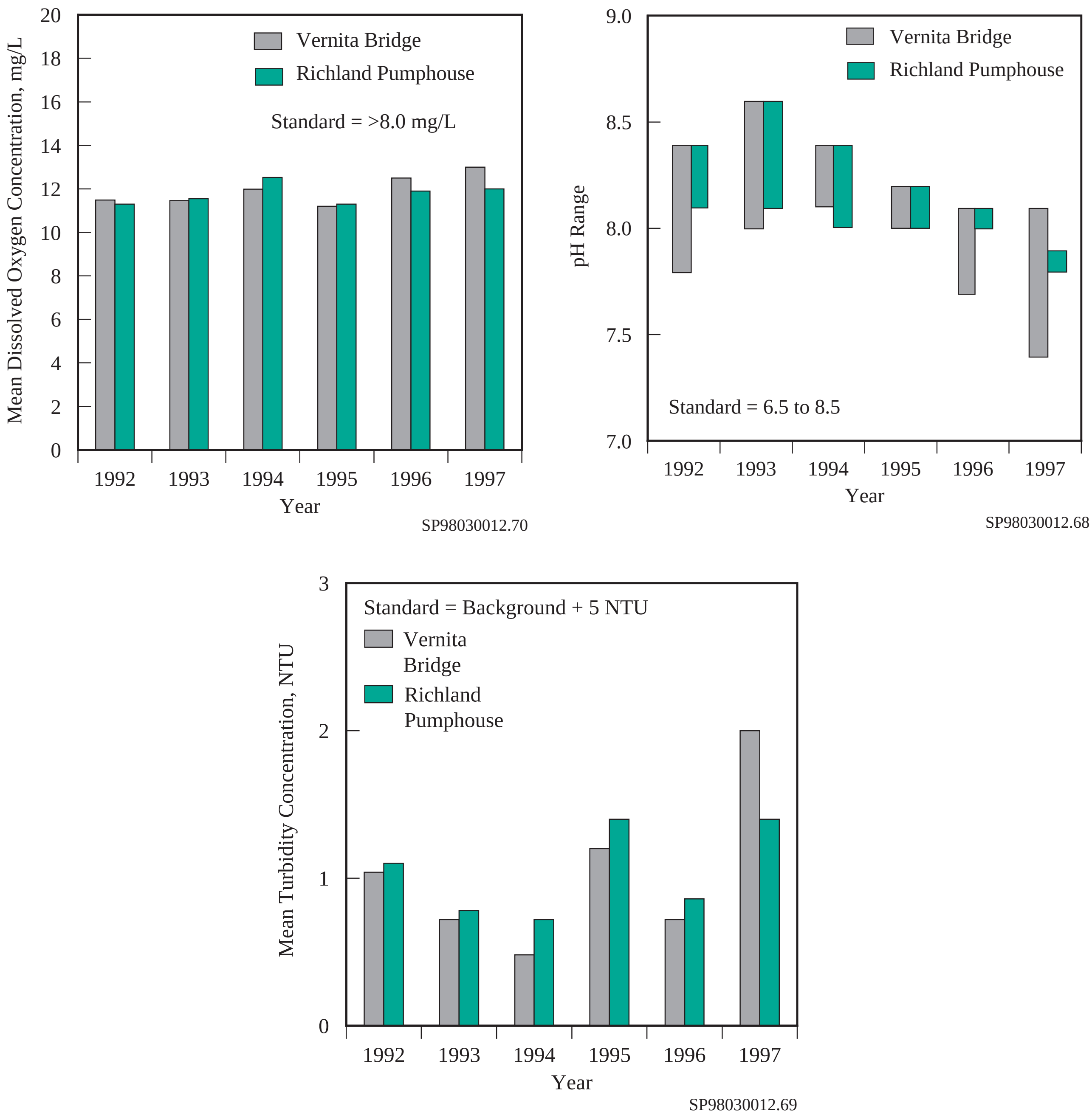

Figure 4.2.10. U.S. Geological Survey Columbia River Water Quality Measurements, 1992 Through 1997 (1997 results are preliminary; NTU = nephelometric turbidity unit)

transects. Nitrate, sulfate, and chloride concentrations were slightly elevated along the Franklin County shoreline of the 300 Area and Richland Pumphouse transects and likely resulted from groundwater seepage associated with extensive irrigation north and east of the Columbia River. Nitrate contamination of some Franklin County groundwater has been documented by the U.S. Geological Survey (1995) and is associated with high fertilizer and water usage. Numerous wells in western Franklin County exceed the EPA maximum contaminant level for nitrate (40 CFR 141). Nitrate, sulfate, and chloride results were slightly higher for average quarterly concentrations at the Richland Pumphouse transect compared to the Vernita Bridge transect.

Washington State ambient surface-water quality criteria for cadmium, copper, lead, nickel, silver, and zinc are total-hardness dependent (WAC 246-290; see Appendix C, Table C.3). Criteria for Columbia River water were calculated using a total hardness of 48 mg/L as $CaCO_3$ (calcium carbonate), the limiting value based on U.S. Geological Survey monitoring of Columbia River water near Vernita Bridge and the Richland Pumphouse over the past 6 years. The total hardness reported by the U.S. Geological Survey at those locations from 1992 through 1997 ranged from 48 to 77 mg/L as $CaCO_3$. All metal and anion concentrations in river water were less than the ambient surface-water quality criteria levels for both acute and chronic toxicity levels (see Appendix C, Table C.3). Arsenic concentrations exceeded EPA standards; however, similar concentrations were found at Vernita Bridge and Richland Pumphouse (see Appendix C, Table C.3).

4.2.2 Columbia River Sediments

Sediments in the Columbia River contain low concentrations of radionuclides and metals of Hanford Site origin as well as radionuclides from nuclear weapons testing fallout (Beasley et al. 1981, BNWL-2305, PNL-8148, PNL-10535). Potential public exposures are well below the level at which routine surveillance of Columbia River sediments is required (PNL-3127, Wells 1994). However, periodic sampling is necessary to confirm the low levels and to ensure that no significant changes have occurred for this pathway. The accumulation of radioactive materials in sediment can lead to human exposure through ingestion of aquatic species, through sediment resuspension into drinking water supplies, or as an external radiation source irradiating people who are fishing, wading, sunbathing, or participating in other recreational activities associated with the river or shoreline (DOE/EH-0173T). As a result of past operations at the Hanford Site, radioactive and nonradioactive materials were discharged to the Columbia River. On release to the river, the materials were dispersed rapidly, sorbed onto detritus and inorganic particles, incorporated into aquatic biota, and deposited on the riverbed as sediment. Fluctuations in the river flow rate, as a result of the operation of hydroelectric dams, annual spring freshets, and occasional floods, have resulted in the resuspension, relocation, and subsequent redeposition of the contaminated sediments (DOE/RL-91-50, Rev. 2).

Since the shutdown of the original single-pass reactors, the contaminant burden in the surface sediments has been decreasing as a result of radioactive decay and the subsequent deposition of uncontaminated material. However, discharges of some pollutants from the Hanford Site to the Columbia River still occur via permit-regulated liquid effluent discharges (see Section 3.1, "Facility Effluent Monitoring") and via contaminated groundwater seepage (DOE/EIS-0119F, PNL-5289, PNL-7500, WHC-SD-EN-TI-006).

A special study was conducted in 1994 to investigate the difference in sediment grain-size composition and total organic carbon content at routine monitoring sites (PNL-10535). Physicochemical sediment characteristics were found to be highly variable among monitoring sites along the Columbia River. Samples containing the highest percentage of silts, clays, and total organic carbon were collected above McNary Dam and from White Bluffs Slough. All other samples primarily consisted of sand. Higher contaminant burdens were generally associated with sediments containing higher total organic carbon and finer grain-size distributions, which is consistent with other sediment investigations (Nelson et al. 1966, Lambert 1967, Richardson and Epstein 1971, Gibbs 1973, Karickhoff et al. 1978, Suzuki et al. 1979, Sinex and Helz 1981, Tada and Suzuki 1982, Mudroch 1983).

4.2.2.1 Collection of Sediment Samples and Analytes of Interest

During 1997, samples of Columbia River surface sediments (0 to 15-cm [0 to 6-in.] depth) were collected from 6 river locations that are permanently submerged and 5 riverbank springs locations that are periodically inundated (see Figure 4.2.1 and Table 4.2.2). Samples were collected upstream of Hanford Site facilities above Priest

Rapids Dam (the nearest upstream impoundment) to provide background data from an area unaffected by site operations. Samples were collected downstream of the Hanford Site above McNary Dam (the nearest downstream impoundment) to identify any increase in contaminant concentrations. Note that any increases in contaminant concentrations found in sediment above McNary Dam relative to that found above Priest Rapids Dam do not necessarily reflect a Hanford Site source. The confluences of the Columbia River with the Yakima, Snake, and Walla Walla Rivers lie between the Hanford Site and McNary Dam. Several towns and factories in these drainages may also contribute to the contaminant load found in McNary Dam sediment. Sediment samples were also collected along the Hanford Reach of the Columbia River from areas close to contaminant discharges (e.g., riverbank springs), from slackwater areas where fine-grained material is known to deposit (e.g., the White Bluffs, 100-F Area, and Hanford Sloughs), and from an area commonly used by the public (e.g., the Richland shoreline).

Monitoring sites located at McNary and Priest Rapids Dams consisted of four stations spaced equidistant on a transect line crossing the Columbia River. All other monitoring sites consisted of a single sampling location. Samples of permanently inundated river sediment, herein referred to as river sediment, were collected using a grab sampler with a 235-cm^2 (36.4 in^2 opening. Samples of periodically inundated river sediment, herein referred to as riverbank springs sediment, were collected using a large plastic spoon, immediately following the collection of riverbank springs water samples. Sampling methods are discussed in detail in DOE/RL-91-50, Rev. 2. All sediment samples were analyzed for gamma emitters (see Appendix E), strontium-90, uranium-235, uranium-238, and metals (DOE/RL-91-50, Rev. 2). River sediment samples were also analyzed for plutonium-238, plutonium-239,240, and simultaneously extracted metals/acid volatile sulfide. Sample analyses of Columbia River sediments were selected based on findings of previous Columbia River sediment investigations, reviews of past and present effluents discharged from site facilities, and reviews of contaminant concentrations observed in near-shore groundwater monitoring wells.

4.2.2.2 Radiological Results for River Sediment Samples

Results of the radiological analyses on river sediment samples collected during 1997 are reported in PNNL-11796 and summarized in Appendix A (Table A.5). Radionuclides consistently detected in river sediment adjacent and downstream of the Hanford Site during 1997 included cobalt-60, strontium-90, cesium-137, europium-155, uranium-238, plutonium-238, and plutonium-239,240. The concentrations of all other measured radionuclides were below detection limits for most samples. Strontium-90 and plutonium-239,240 exist in worldwide fallout, as well as in effluents from Hanford Site facilities. Uranium occurs naturally in the environment in addition to being present in Hanford Site effluents. Comparisons of contaminant concentrations between sediment sampling locations are made below. Because of variations in the bioavailability of contaminants in various sediments, no state or federal freshwater sediment criteria are available to assess the sediment quality of the Columbia River (EPA 822-R-96-001).

Radionuclide concentrations reported in river sediment in 1997 were similar to those reported for previous years (see Appendix A, Table A.5). No appreciable differences in isotopic uranium concentrations were noted between locations. Minimum, median, and maximum concentrations of select radionuclides measured in river sediment from 1992 through 1997 are presented in Figure 4.2.11. Sampling areas include stations at Priest Rapids and McNary Dams as well as the Hanford Reach stations (White Bluffs, 100-F Area, Hanford Sloughs, and Richland Pumphouse). Strontium-90 was the only radionuclide to exhibit consistently higher median concentrations at McNary Dam from 1992 through 1997. The rank of all other radionuclide concentrations by sampling area varied from year to year. No other radionuclides measured in 1997 exhibited appreciable differences in concentrations between locations.

4.2.2.3 Radiological Results for Riverbank Springs Sediment Samples

Riverbank springs sediment sampling was initiated in 1993 at the Old Hanford Townsite and 300 Area. Sampling of the riverbank springs in the 100-B, 100-F, and 100-K Areas was initiated in 1995. Sediments at all other riverbank springs sampling locations consisted of predominantly large cobble and were unsuitable for sample collection.

Radiological results for riverbank springs sediment collected in 1997 are presented in PNNL-11796 and are summarized in Appendix A (Table A.5). Results were similar to those observed for previous years, with the

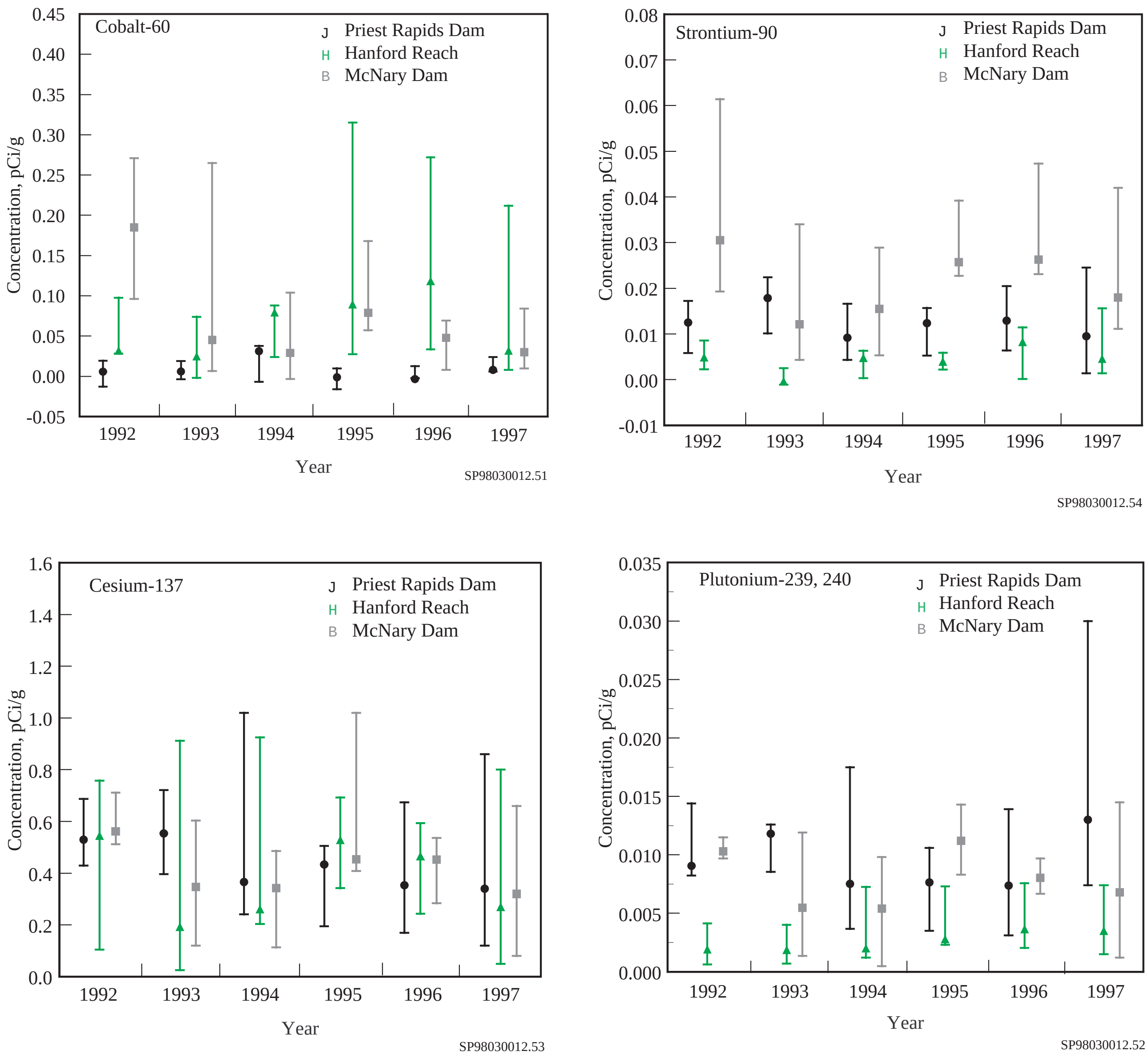

Figure 4.2.11. Minimum, Median, and Maximum Concentrations of Selected Radionuclides Measured in Columbia River Sediments, 1992 Through 1997

exception of total uranium in 300 Area spring sediment that did not show the elevated concentrations reported in 1995. Radionuclide concentrations in riverbank springs sediment were similar to those observed in river sediment in 1997.

4.2.2.4 Nonradiological Results for Columbia River Sediment Samples

Metal concentrations (total metals, reported on a dry weight basis) observed in Columbia River sediment in 1997 are reported in PNNL-11796 and are summarized in Appendix A (Table A.6). Detectable amounts of most metals were found in all Columbia River sediment samples. Overall median concentrations of most metals were similar for most samples (Figure 4.2.12). The maximum and highest median concentrations of chromium were found in riverbank springs sediment.

In 1997, the Columbia River sediment was also analyzed for simultaneously extracted metals/acid volatile sulfide (SEM/AVS). This analysis involves a cold acid extraction of the sediments followed by analysis for sulfide and

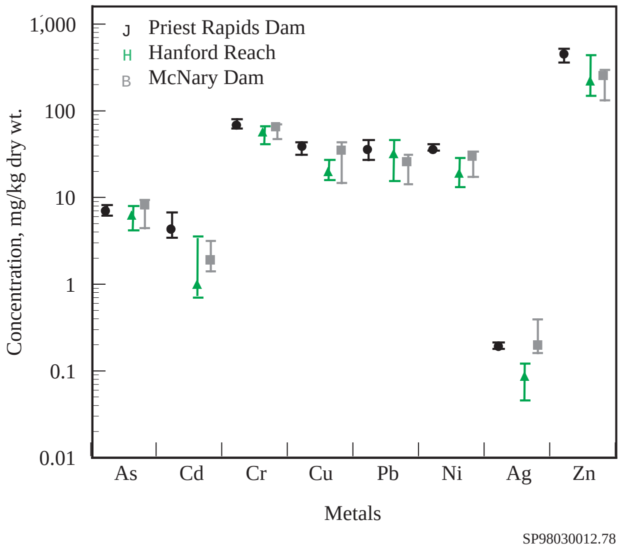

Figure 4.2.12. Minimum, Median, and Maximum Concentrations of Selected Metals Measured in Columbia River Sediments, 1997

metals. The SEM/AVS ratios are typically a better indicator of sediment toxicity than total metal concentrations (DeWitt et al. 1996, Hansen et al. 1996). Acid volatile sulfide is usually the dominant binding phase for metals in sediment, and metal sulfide precipitates can form that are very insoluble in sediment porewater. When the amount of acid volatile sulfide exceeds the amount of the metals (i.e., the SEM/AVS molar ratio is below 1), the metal concentration in the porewater will be low because of the limited solubility of the metal sulfide. Acid volatile sulfide ranged from 1.2 to 21 µmole/g and SEM/AVS ratios were 0.0086 to 0.20 for copper and 0.21 to 1.4 for zinc. The SEM/AVS ratios for mercury, cadmium, nickel, and lead were all below 0.05.

4.2.3 Riverbank Springs Water

The Columbia River is the primary discharge area for the unconfined aquifer underlying the Hanford Site (Chapter 2.0 in PNL-10698). Groundwater provides a means for transporting Hanford-associated contaminants, which have leached into groundwater from past waste disposal practices, to the Columbia River (DOE/RL-92-12, PNL-5289, PNL-7500, WHC-SD-EN-TI-006). Contaminated groundwater enters the Columbia River via surface and subsurface discharge. Discharge zones located above the water level of the river are identified in this report as riverbank springs. Routine monitoring of riverbank springs offers the opportunity to characterize the quality of groundwater being discharged to the river and to assess the potential human and ecological risk associated with the spring water.

The seepage of groundwater into the Columbia River has occurred for many years. Riverbank springs were documented along the Hanford Reach long before Hanford Site operations began during World War II (Jenkins 1922). In 1984, researchers walked the 66-km (41-mi) stretch of Benton County shoreline of the Hanford Reach in 1983 and identified 115 springs (PNL-5289). They reported that the predominant areas of groundwater discharge at that time were in the vicinity of the 100-N Area, Old Hanford Townsite, and 300 Area. The predominance of the 100-N Area may no longer be valid because of declining water-table elevations in response to the decrease in liquid waste discharges to the ground from Hanford Site operations. In recent years, it has become increasingly difficult to locate riverbank springs in the 100-N Area.

The presence of riverbank springs also varies with river stage. Groundwater levels in the 100 and 300 Areas are heavily influenced by river stage fluctuations (see Section 6.1, "Hanford Groundwater Monitoring Project"). Water levels in the Columbia River fluctuate greatly on annual and even daily cycles and are controlled by the operation of Priest Rapids Dam upstream of the site. Water flows into the aquifer (as bank storage) as the river stage rises and flows in the opposite direction as the river stage falls. Following an extended period of low river discharge, groundwater discharge zones located above the water level of the river may cease to exist once the level of the groundwater comes into equilibrium with the level of the river. Thus, springs are most readily identified immediately following a decline in river stage. Bank storage of river water also affects the contaminant concentration of the springs. Spring water discharge immediately following a river stage decline generally consists of river water or a river groundwater mix. The percent contribution of groundwater to spring water discharge is believed to increase over time following a drop in river stage.

Because of the effect of bank storage on groundwater discharge and contaminant concentration, it is difficult to estimate the volume of contaminated groundwater discharged to the Columbia River within the Hanford Reach. The estimated total groundwater discharge from the upstream end of the 100 Areas to south of the 300 Area is approximately 66,500 m^3/d (2,350,000 ft^3/d).[a] This amount is 0.02% of the long-term average flow rate of the Columbia River, which illustrates the tremendous dilution potential offered by the river. It should be noted that not all of the groundwater discharged to the river contains contaminants originating from Hanford Site operations. Riverbank springs studies conducted in 1983 (PNL-5289) and in 1988 (PNL-7500) noted that spring discharges had a localized effect on river contaminant concentrations. Both studies reported that the volume of groundwater entering the river at these locations was very small relative to the flow of the river and that the impact of groundwater discharges to the river was minimal.

4.2.3.1 Riverbank Springs Water Samples and Analytes of Interest

Routine monitoring of selected riverbank springs was initiated in 1988 at the 100-N Area, Old Hanford Townsite, and 300 Area. Monitoring was expanded in 1993 to include riverbank springs in the 100-B, 100-D, 100-H, and 100-K Areas. A 100-F Area riverbank spring was added in 1994. The locations of all riverbank springs sampled in 1997 are identified in Figure 4.2.1. Sample collection methods are described in DOE/RL-91-50, Rev. 2. Analytes of interest for samples from riverbank springs were selected based on findings of previous investigations, reviews of contaminant concentrations observed in nearby groundwater monitoring wells, and results of preliminary risk assessments. Sampling is conducted annually when river flows are low, typically August through September.

For 1997, high Columbia River flows delayed sample collections until late October and November. The 100-H Area spring was under water during all sampling attempts in 1997, so an alternate spring was sampled approximately 150 m (500 ft) downriver. Samples from riverbank springs collected during 1997 were analyzed for gamma-emitting radionuclides, gross alpha, gross beta, and tritium. Samples from selected springs were analyzed for strontium-90, technetium-99, iodine-129, and uranium-234,235,238. Samples were also analyzed for metals and anions. All analyses were conducted on unfiltered samples.

4.2.3.2 Results for Riverbank Springs Water

Hanford-origin contaminants continued to be detected in riverbank springs water entering the Columbia River along the Hanford Site during 1997. The locations and extent of contaminated discharges were consistent with recent groundwater surveys. Tritium, strontium-90, technetium-99, iodine-129, uranium-234,235,238, metals (antimony, arsenic, cadmium, copper, lead, nickel, selenium, thallium, zinc, and occasionally silver), and anions (chloride, fluoride, nitrate, and sulfate) were detected in spring water. The contaminant concentrations in spring water are typically lower than those found in near-shore groundwater wells because of bank storage effects.

Results of radiological and chemical analyses conducted on riverbank springs samples in 1997 are documented in PNNL-11796. Radiological results obtained in 1997 are summarized in Appendix A (Table A.7) and compared to those reported in 1992 through 1996. In the following discussion, radiological and nonradiological results are addressed separately. Contaminant concentration trends are illustrated for locations for which more than 3 years of data are available.

4.2.3.3 Radiological Results for Riverbank Springs Water Samples

All radiological contaminant concentrations measured in riverbank springs in 1997 were less than the DOE derived concentration guides, except for strontium-90 at the 100-N Area where one spring was nearly 10 times the standard (DOE Order 5400.5; see Appendix C, Table C.5). However, the DOE derived concentration guide uses an annual consumption scenario that is not possible at this location because the spring is typically under water. Strontium-90 concentrations at the 100-N Area riverbank spring exceeded the ambient surface-water quality criteria levels (WAC-246-290). Tritium concentrations in riverbank springs water at the Old Hanford Townsite exceeded the ambient surface-water quality criteria levels (WAC 246-290; see Appendix C, Table C.1) and were close to the criteria levels in springs at the 100-N and 100-B Areas. There are no ambient surface-water quality criteria levels directly applicable to uranium. However, total uranium concentrations exceeded the site-specific

(a) Stuart Luttrell, Pacific Northwest National Laboratory, Richland, Washington, January 1995.

proposed EPA drinking water standard (EPA 822-R-96-001) in the 300 Area (see Appendix C, Table C.2). The gross alpha concentration exceeded the ambient surface-water quality criteria level (WAC 246-290) in riverbank spring water at the 300 Area, which is consistent with the elevated uranium levels. All other radionuclide concentrations in 300 Area spring water were less than ambient surface-water quality criteria levels. Gross beta concentrations in riverbank springs water were elevated at the 100-H Area, 100-N Area, and Old Hanford Townsite, but were below surface-water quality criteria levels at all locations. The range of concentrations of selected radionuclides measured in riverbank springs water from 1992 through 1997 is presented in Table 4.2.3.

Tritium concentrations varied widely with location. The highest tritium concentration detected in riverbank springs water was at the Old Hanford Townsite (56,000 ± 4,200 pCi/L), followed by the 100-N Area (19,000 ± 1,500 pCi/L), 100-B Area (11,000 ± 910 pCi/L), and 300 Area (7,900 ± 680 pCi/L). The ambient surface-water quality criteria level for tritium is 20,000 pCi/L (WAC 246-290). Tritium concentrations in all riverbank springs water samples were elevated compared to the 1997 average Columbia River concentrations at Priest Rapids Dam (28 ± 2.3 pCi/L).

Samples from riverbank springs in the 100-B Area, 100-H Area, 300 Area, and Old Hanford Townsite were analyzed for technetium-99. The highest technetium-99 concentration was found in water from the Old Hanford Townsite spring (43 ± 5.1 pCi/L), in agreement with the observed beta activity.

Iodine-129 was detected in the Old Hanford Townsite and 300 Area riverbank springs; the highest concentration was found in water from the Old Hanford Townsite spring (0.14 ± 0.0081 pCi/L). This value was elevated compared to the 1997 average concentration measured at Priest Rapids Dam (0.0000072 ± 0.0000012 pCi/L) but was below the 1-pCi/L surface-water quality criteria level (see Appendix C, Table C.2).

Uranium was found in all riverbank springs samples in 1997, and the highest concentration was found for the 300 Area spring (53 ± 5.6 pCi/L), which is downgradient from the retired 300 Area process trenches. The 300 Area spring had elevated concentrations of gross alpha activity, which paralleled that of uranium.

Samples were analyzed for strontium-90 from riverbank springs in the 100-B, 100-D, 100-F, 100-H, 100-K, and 100-N Areas. The ambient surface-water quality criteria level of 8 pCi/L for strontium-90 was exceeded at 100-N Area (9,900 ± 1,800 pCi/L) and 100-H Area (17 ± 3.1 pCi/L). Beta activity paralleled that of strontium-90 at the 100-N and 100-H Areas. Results are consistent with those found in previous years.

Riverbank seepage in the 100-N Area has been monitored for contaminants by sampling from either the 199-N-8T monitoring well, which is located close to the river, the 199-N-46 monitoring well (caisson), which is slightly inland from well 199-N-8T (see Figure 3.2.4), or riverbank springs. In 1992, the sample was collected from well 199-N-46. From 1993 to 1997, 100-N Area seepage samples were collected from riverbank springs. Sampling in this manner is consistent with the sampling protocol at other riverbank springs. For 1993 to 1996, there was no visible riverbank spring directly adjacent to wells 199-N-8T or 199-N-46 during the sampling period. The 100-N Area riverbank spring samples were instead collected from the nearest visible downstream riverbank spring. In 1997, a sample was collected from the riverbank spring directly adjacent to well 199-N-8T and also from the riverbank spring sampled from 1993 to 1996. Contaminant concentrations measured in the water from the two riverbank springs locations were distinctly different (Table 4.2.4). The concentrations of strontium-90 and gross beta were considerably higher in the spring directly adjacent to well 199-N-8T and were similar to the 1992 groundwater samples from well 199-N-46. Tritium concentrations in riverbank springs water were elevated at both locations and were similar to those found in previous years (see Table 3.2.5). Tritium and strontium-90 were the only contaminants detected at the 100-N Area riverbank spring in 1997. The maximum tritium and strontium-90 concentrations were 0.95 and 1,200 times the ambient surface-water quality criteria levels, respectively (WAC 246-290; see Appendix C, Table C.3). The results for the 100-N Area riverbank spring samples are of the same magnitude as those reported in Section 3.2, "Near-Facility Environmental Monitoring," Table 3.2.5.

Concentrations of selected radionuclides in riverbank springs water near the Old Hanford Townsite from 1992 through 1997 are provided in Figure 4.2.13. Gross beta and technetium-99 concentrations in 1997 were similar to those observed since 1994 and were slightly lower than those observed prior to 1994. The 1997 tritium concentration was slightly higher than in recent years but well below values reported for 1992 and 1993. Annual fluctuations in these tritium concentrations may reflect

Table 4.2.3. Range of Radiological Data for Riverbank Springs, 1992 Through 1997

Spring Location	No. of Samples	Concentration, pCi/L						
		Gross Alpha	Gross Beta	Iodine-129	Strontium-90	Technetium-99	Tritium	Total Uranium
100-B	7	1.1 - 3.5	6.5 - 38	NS[a]	-0.11 - 0.072	5.8 - 25	11,000 - 24,000	NS
100-K	4	0.56 - 1.6	1.4 - 3.6	NS	-0.031 - 0.59	-0.031 - 0.8	110 - 20,000	NS
100-N Spring 8-13	6	0.043 - 8.1	1.5 - 8.8	NS	-0.010 - 0.59	NS	12,000 - 31,000	NS
100-N Spring (below well 199-N-8T	1	2.8	16,000	NS	9,900	NS	14,000	NS
100-D	8	0.27 - 2.9	2.1 - 21	NS	0.069 - 9.4	NS	87 - 13,000	NS
100-H	6	2.4 - 4.6	33 - 69	NS	12 - 25	18 - 140	430 - 1,200	0.52 - 2.7
100-F	4	2.6 - 41	-4.6 - 65	NS	-0.03 - 0.099	NS	620 - 1,800	3.4 - 9.2
Hanford Spring 28-2	8	0.10 - 4.9	4.8 - 95	0.044 - 0.22	NS	2.0 - 130	6,300 - 170,000	1.6 - 4.6[b]
300 Area Spring 42-2	8	13 - 110	3.3 - 29	0.0019 - 0.0055[c]	NS	0.50 - 14[b]	1,300 - 12,000	24 - 130
Ambient surface-water quality criteria level		15[d,e]	50[d]	1[f]	8[d]	900[f]	20,000[d]	20[f]

(a) No sample.
(b) Seven samples analyzed.
(c) Five samples analyzed.
(d) WAC 246-290 and 40 CFR 141.
(e) Ambient surface-water quality criteria level for gross alpha excludes uranium contribution.
(f) Proposed standard (EPA 822-R-96-001).

Table 4.2.4. Selected Radionuclide Concentrations in 100-N Area Riverbank Springs Water, 1992 Through 1997

	Concentration, pCi/L[a]		
Year	Tritium	Gross beta	Strontium-90
1992[b]	4,900 ± 500	24,000 ± 1,700	11,000 ± 2,000
1993[c]			
Min	28,000 ± 2,200	2.4 ± 3.2	-0.010 ± 0.22
Max	29,000 ± 2,300	4.5 ± 3.3	0.020 ± 0.26
1994[c]	31,000 ± 2,400	8.8 ± 2.3	0.13 ± 0.11
1995[c]	12,000 ± 970	1.5 ± 1.5	0.079 ± 0.10
1996[c]	17,000 ± 1,300	4.5 ± 1.8	0.053 ± 0.048
1997[c]	19,000 ± 1,500	3.5 ± 1.6	0.59 ± 0.13
1997[d]	14,000 ± 1,100	16,000 ± 1,400	9,900 ± 1,800

(a) Concentrations are ±2 total propagated analytical uncertainty.
(b) Sample collected from well 199-N-46 (see Figure 3.2.4).
(c) Sample collected from riverbank spring downstream of well 199-N-8T (100-N Area spring 8-13).
(d) Samples collected from spring below well 199-N-8T (see Figure 3.2.5).

the influence of bank storage during the sampling period. Tritium and technetium-99 concentrations detected in Old Hanford Townsite riverbank springs water in 1997 were 280% and 4.8% of their respective ambient surface-water quality criteria levels (WAC 246-290; see Appendix C, Table C.3). The iodine-129 concentration measured in the Old Hanford Townsite riverbank springs water for 1997 was 14% of the ambient surface-water quality criteria level (WAC 246-290; see Appendix C, Table C.3).

Figure 4.2.14 depicts the concentrations of selected radionuclides in the 300 Area riverbank springs from 1992 through 1997. Results in 1997 were similar to those observed previously. The elevated tritium concentrations measured in the 300 Area riverbank springs are indicators of the contaminated groundwater plume emanating from the 200 Areas (Section 5.9 in PNL-10698). Technetium-99 and iodine-129 are also contained in the 200 Areas' contaminated groundwater plume. Tritium, technetium-99, and iodine-129 concentrations in 300 Area riverbank springs water in 1997 were 40%, 0.98%, and 0.55% of their respective ambient surface-water quality criteria levels (WAC 246-290; see Appendix C, Table C.3). The highest total uranium concentrations in riverbank springs water from 1992 through 1997 were found in the 300 Area riverbank springs, with the 1997 concentration four times higher than the proposed site-specific EPA drinking water standard (13.4 pCi/L [EPA 822-R-96-001]; see Appendix C, Table C.2). Elevated uranium concentrations exist in the unconfined aquifer beneath the 300 Area in the vicinity of uranium fuel fabrication facilities and inactive waste sites. Gross alpha and gross beta concentrations in the 300 Area riverbank springs water from 1992 through 1997 parallel that of uranium and are likely associated with its presence.

4.2.3.4 Nonradiological Results for Riverbank Springs Water Samples

The range of concentrations of selected chemical compounds measured in riverbank springs water in 1993 through 1997 are presented in Table 4.2.5. For most locations, the 1997 nonradiological sample results were slightly lower than those previously reported. This may be the result of increased bank storage during an extremely high water year for the Columbia River. The 1997 nitrate concentrations at all spring locations were the lowest reported since 1993, except for the 100-D Area spring that was within the previous range of values. Nitrate concentrations were highest in the 100-F and 100-H Area springs. Chromium concentrations were highest in the 100-D, 100-F, and 100-H Areas' riverbank springs. Hanford groundwater monitoring results for 1997 indicated similar nonradiological contaminants in shoreline areas (see Section 6.1, "Hanford Groundwater Monitoring Project").

The ambient surface-water quality criteria for cadmium, copper, lead, nickel, silver, and zinc are total-hardness dependent (WAC 173-201A; see Appendix C, Table C.3). For comparison purposes, spring water criteria were calculated using the same 48-mg $CaCO_3$/L hardness given in Table C.3. The sampling protocol used did not lend itself to a direct comparison of most metal concentrations in riverbank springs to ambient surface-water acute and chronic toxicity levels because of different time frames (DOE/RL-91-50, Rev. 2). The standards are instead used as a point of reference. Metal concentrations measured in riverbank springs from the Hanford Site shoreline in 1997 were below ambient surface-water acute toxicity levels (WAC 173-201A), except for chromium concentrations in 100-D and 100-H Areas riverbank springs (see Appendix C, Table C.3). Spring water from the 100-B, 100-D, 100-F, and 100-H Areas exceeded the chronic toxicity standard for chromium (see Appendix C, Table C.3). Lead concentrations were above the chronic toxicity standard in the 100-F and 100-K Areas (see Appendix C,

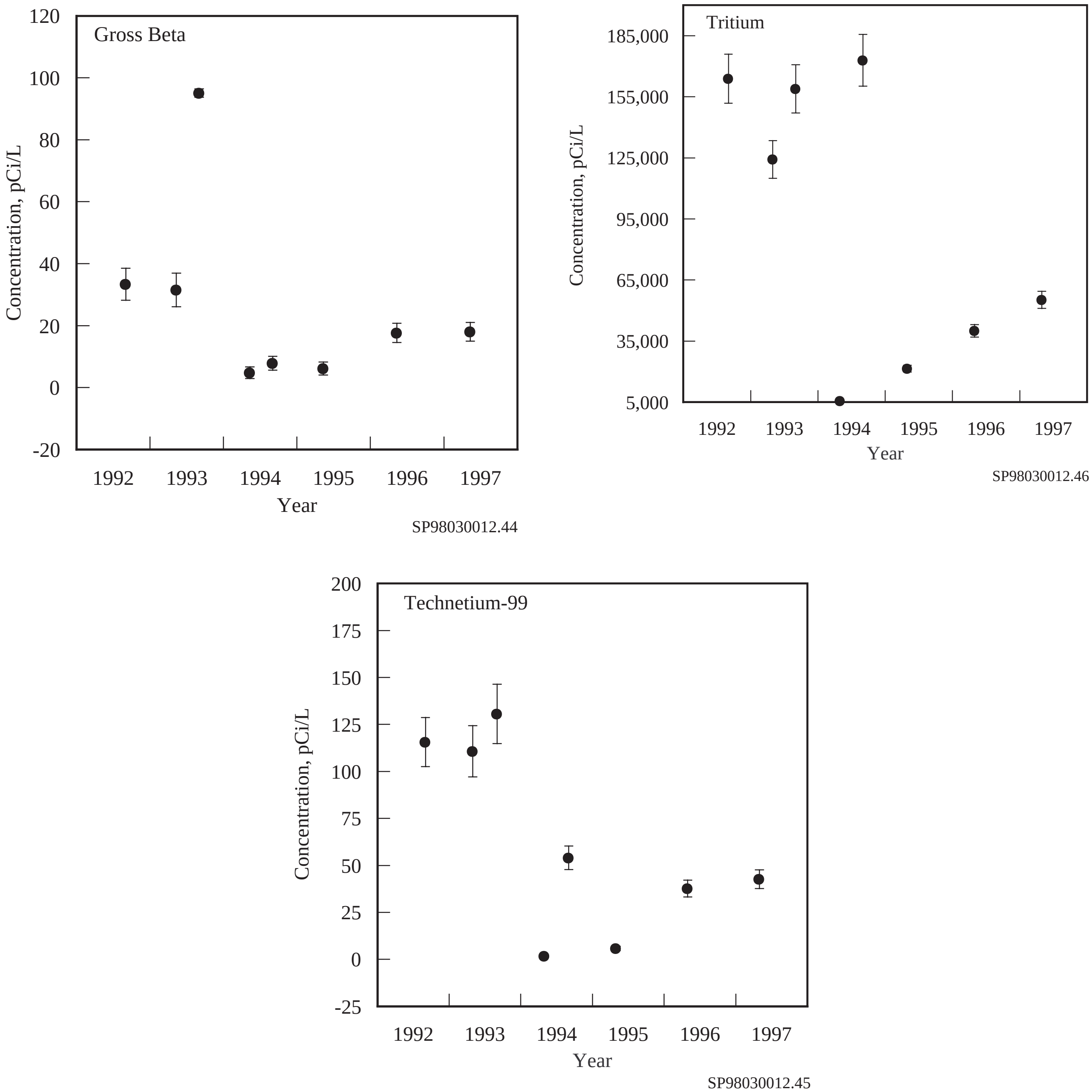

Figure 4.2.13. Concentrations (results ±2 total propagated analytical uncertainty) of Constituents of Interest in Riverbank Springs Water Near the Old Hanford Townsite, 1992 Through 1997. As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.

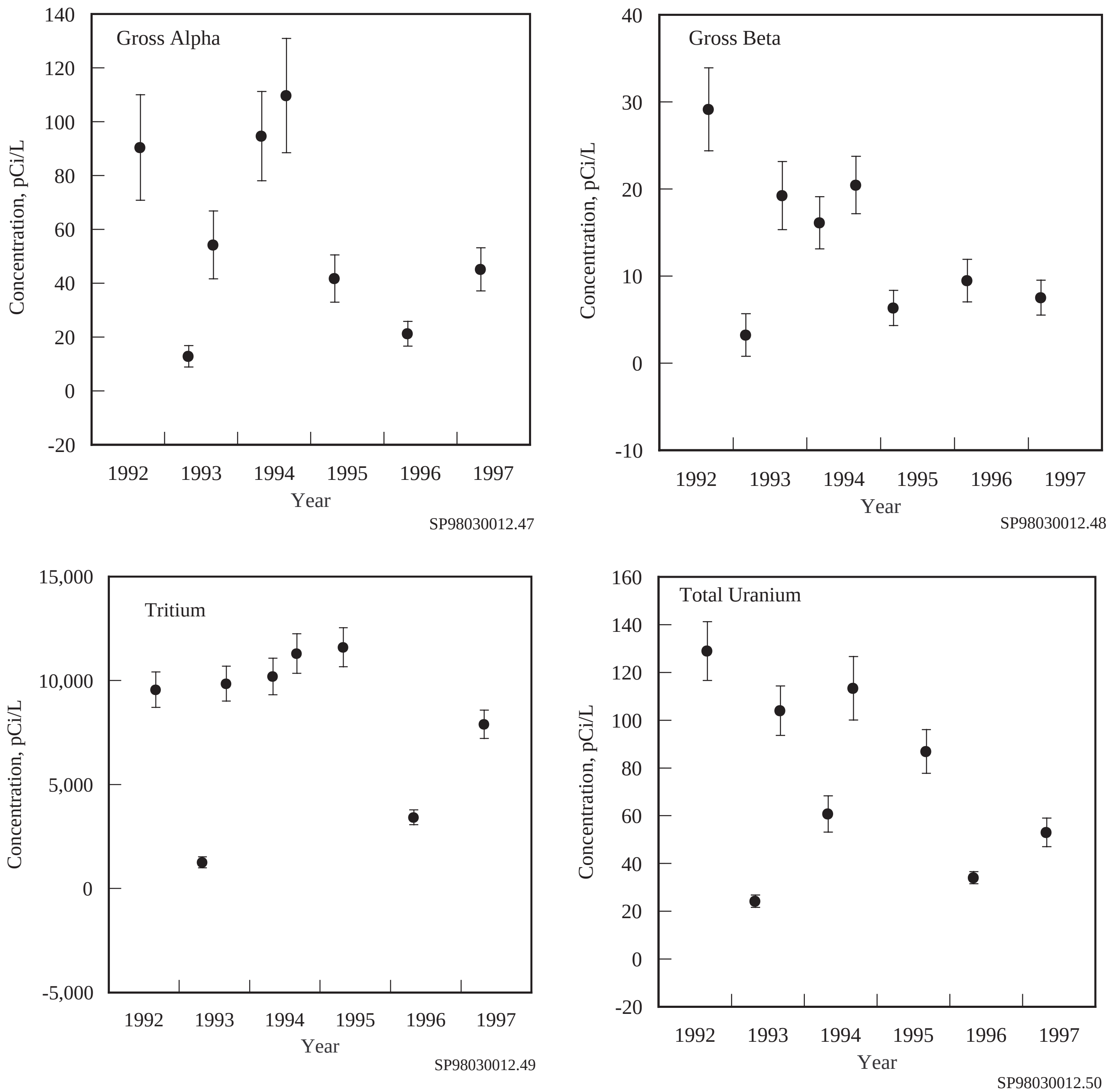

Figure 4.2.14. Concentrations (results ±2 total propagated analytical uncertainty) of Constituents of Interest in 300 Area Riverbank Spring Water, 1992 Through 1997

Table 4.2.5. Concentration Ranges of Selected Nonradiological Compounds in Riverbank Springs, 1993 Through 1997

	Ambient Surface-Water Quality Criteria Level, µg/L	Concentration, µg/L							
		100-B Area	100-K Area	100-N Area[a]	100-D Area	100-H Area	100-F Area	Old Hanford Townsite	300 Area
No. of Samples		5	2	4	6	4	4	5	4
Metals									
Antimony[b]		0.24	0.42	0.24	0.36	0.31	0.17	0.42	0.28
Arsenic[b]	190	1.3	1.2	2.5	1.0	0.90	2.2	3.2	1.3
Cadmium	[c]	0.031 - 0.72	0.067 - 2.0	ND[d] - 0.038	ND - 0.035	ND - 0.033	0.10 - 4.8	ND	ND - 0.055
Chromium	[c]	13 - 25	1.7 - 66	ND - 45	ND - 400	18 - 55	6.0 - 99	ND - 2.5	ND - 6.4
Copper	[c]	ND - 0.36	1.1 - 37	ND - 30	ND - 6.4	ND - 4.7	ND - 85	ND - 5.4	ND - 14
Lead[b]	[c]	0.90	2.5	0.35	0.41	0.37	1.9	0.22	0.95
Nickel	[c]	ND - 8.1	ND - 0.83	ND - 25	ND - 26	ND - 1.1	ND - 31	ND - 22	ND - 1.3
Selenium[b]	5	2.9	0.89	0.58	1.0	0.96	3.0	1.8	2.8
Thallium[b]	[c]	0.0088	0.047	0.023	0.072	0.044	0.025	0.035	0.045
Zinc	[c]	ND - 45	4.7 - 410	1.2 - 460	1.3 - 18	1.7 - 15	6.0 - 910	0.66 - 32	4.0 - 100
Anions									
Nitrate		4,000 - 11,000	320 - 15,000	3,100 - 15,000	1,000 - 46,000	5,800 - 47,000	9,000 - 33,000	1,800 - 40,000	4,000 - 23,000

(a) Sample collected from riverbank spring downstream of well 199-N-8T (see Table 4.2.4).
(b) 1997 value only (n=1).
(c) Ambient surface-water quality criteria level is hardness-dependent (WAC 173-201A-040; see Appendix C, Table C.3).
(d) ND indicates result was less than the minimum detection level.

Table C.3). The riverbank spring near the 100-F Area had the highest nitrate concentration; however, nitrate concentrations at all spring water locations were below the drinking water standards (see Appendix C, Table C.2).

4.2.4 Onsite Pond Water

Three onsite ponds (see Figure 4.2.1), located near operational areas, were sampled periodically during 1997. B Pond near the 200-East Area was constructed in the mid-1950s and expanded in the 1980s for disposal of process cooling water and other liquid wastes that occasionally contained low levels of radionuclides. B Pond was a series of four ponds: 216-B-3 (main pond) and the 216-B-3A, -3B, and -3C Expansion Ponds. Before October 1994, B Pond samples were collected from 216-B-3. However, 216-B-3 and -3A were decommissioned in 1994, and 216-B-3B was never active, though it did receive one accidental discharge. The 216-B-3C Expansion Pond was decommissioned in late 1997. The Fast Flux Test Facility Pond near the 400 Area was excavated in 1978 for the disposal of cooling and sanitary water from various facilities in the 400 Area. Sanitary water is now piped to the Washington Public Power Supply System treatment facility, and the pond has been drained and backfilled. Fast Flux Test Facility pond samples are currently collected from a pond (located just east of the 1978 pond) that is a disposal site for process water (primarily cooling tower water). West Lake, the only naturally occurring pond onsite, is located north of the 200-East Area (ARH-CD-775). West Lake has not received direct effluent discharges from site facilities but is influenced by changing water table elevation.

The site management and integration contractor is responsible for monitoring effluents discharged to the ponds. Although the ponds are inaccessible to the public and did not constitute a direct offsite environmental impact during 1997, they were accessible to migratory waterfowl, thus creating a potential biological pathway for the dispersion of contaminants (PNL-10174). Periodic sampling of the ponds also provided an independent check on effluent control and monitoring systems.

4.2.4.1 Collection of Pond Water Samples and Analytes of Interest

In 1997, grab samples were collected quarterly from B Pond (i.e., 216-B-3C Expansion Pond), Fast Flux Test Facility Pond, and West Lake. Unfiltered aliquots of all samples were analyzed for gross alpha and gross beta activities, gamma-emitting radionuclides, and tritium. Samples from B Pond were also analyzed for strontium-90. West Lake samples were also analyzed for strontium-90, technetium-99, and uranium-234,235,238. Constituents were chosen for analysis based on their known presence in local groundwater and in effluents discharged to the ponds and their potential to contribute to the overall radiation dose to the public.

4.2.4.2 Radiological Results for Pond Water Samples

Analytical results from pond samples collected during 1997 are reported in PNNL-11796. With the exceptions of uranium-234 and uranium-238 in the July sample from West Lake, radionuclide concentrations in onsite pond water were less than the DOE derived concentration guides (DOE Order 5400.5; see Appendix C, Table C.5). Median concentrations of gross beta and total uranium exceeded the ambient surface-water quality criteria level in West Lake. The median concentrations of all other radionuclides were below ambient surface-water quality criteria levels (WAC 246-290; see Appendix C, Table C.2).

Annual concentrations of selected radionuclides in B Pond water for the years 1992 through 1997 are shown in Figure 4.2.15. B Pond samples in 1997 were collected from the 216-B-3C Expansion Pond until July when it was drained and decommissioned. Median concentrations of gross alpha, gross beta, tritium, and strontium-90 in 1997 were 2.0%, 3.0%, 0.85%, and 1.3% of ambient surface-water quality criteria levels, respectively (WAC 246-290). All other measured radionuclides were detected at concentrations greater than two times their total propagated analytical uncertainty in less than 25% of samples collected.

Figure 4.2.16 shows the annual gross beta and tritium concentrations in Fast Flux Test Facility Pond water from 1992 through 1997. Median concentrations of both constituents have remained stable in recent years. However, the tritium concentration in the July 1995 sample was 16,400 pCi/L, which was much higher than that observed previously. During this time, emergency water supply well 499-S0-7 was in use. Tritium levels in well 499-S0-7 are typically above 20,000 pCi/L, reflective of those observed in a portion of the local unconfined aquifer. The use of well 499-S0-7 is most likely responsible for the high levels of tritium observed in July 1995. Median concentrations of gross beta and tritium in Fast Flux Test Facility Pond water during 1997 were 28% and 21% of their respective ambient surface-water quality

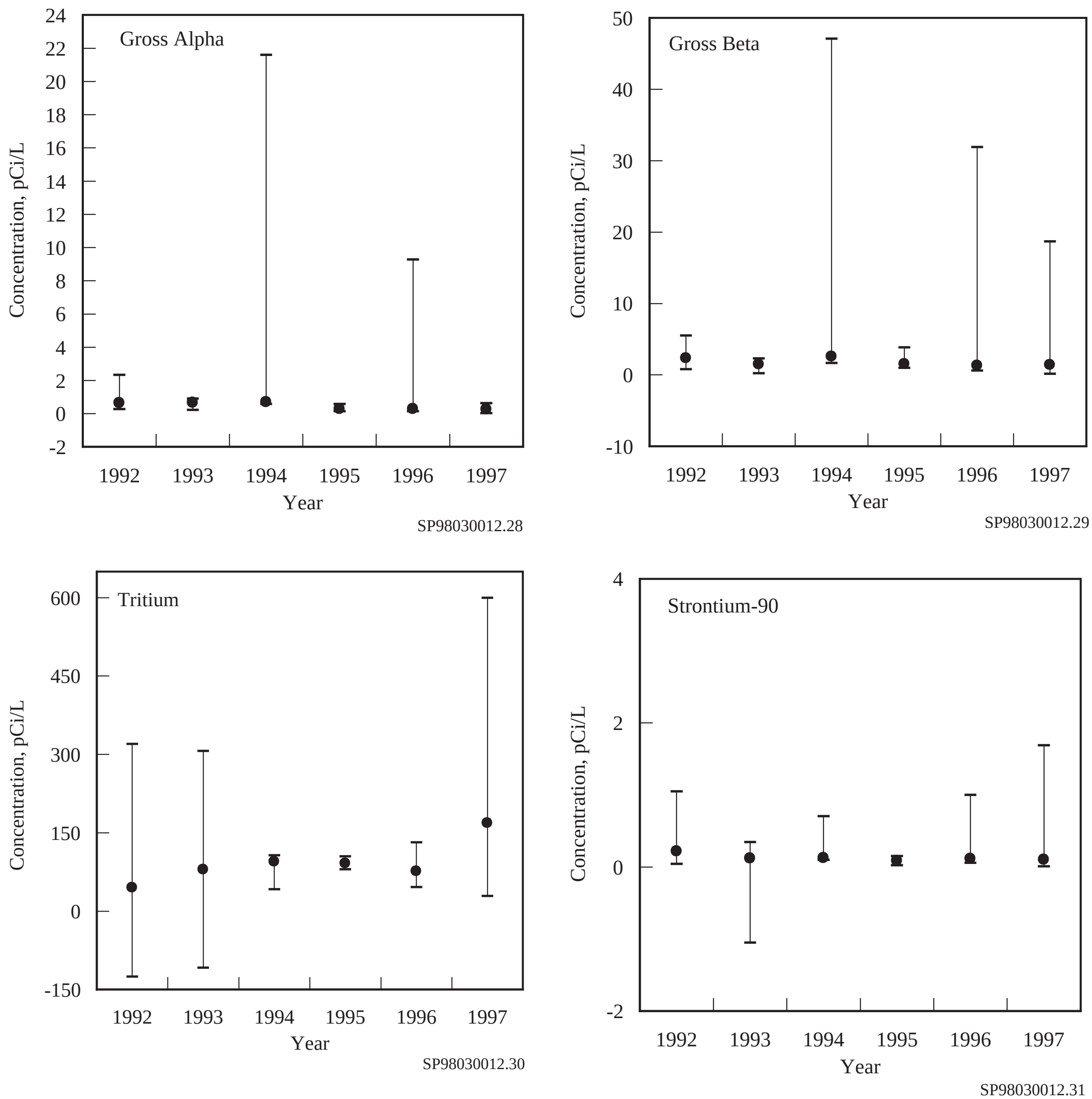

Figure 4.2.15. Minimum, Median, and Maximum Concentrations of Selected Radionuclides in B Pond Water, 1992 Through 1997

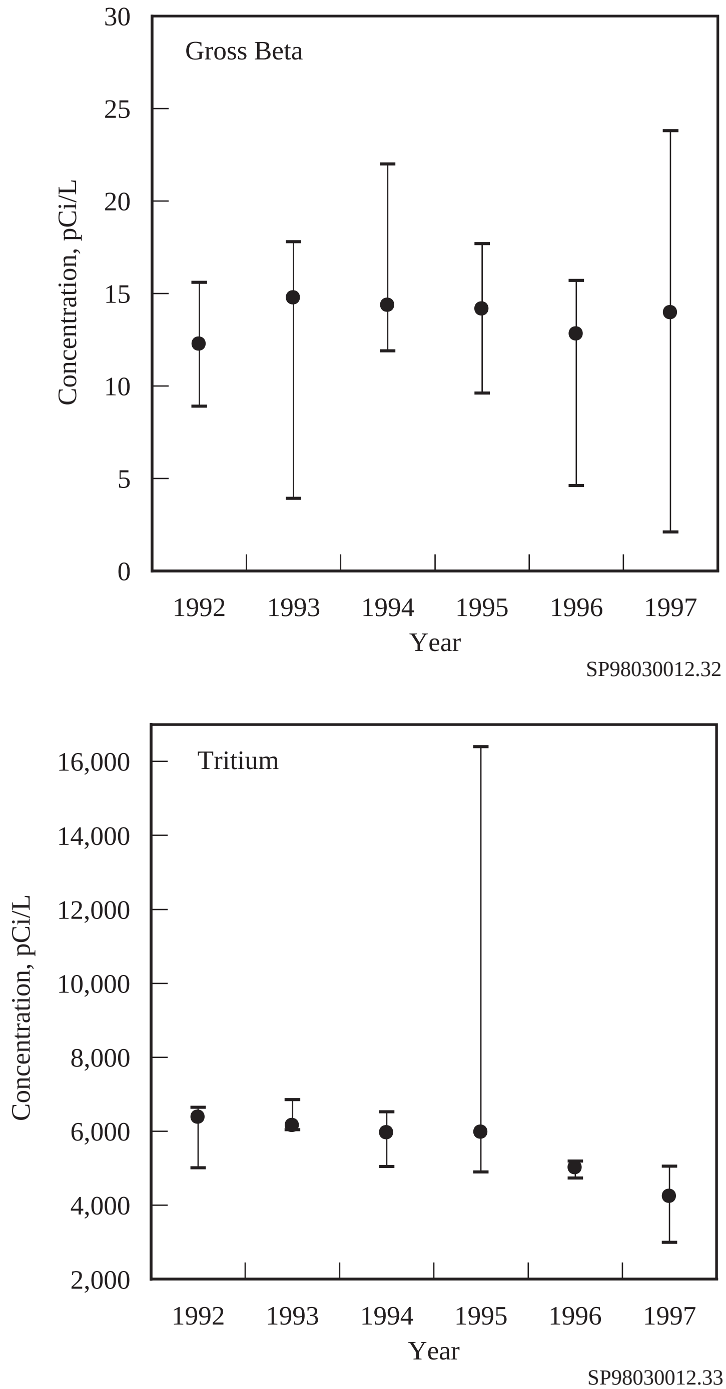

Figure 4.2.16. Minimum, Median, and Maximum Gross Beta and Tritium Concentrations in Fast Flux Test Facility Pond Water, 1992 Through 1997

criteria levels (WAC 246-290). The concentrations of all other measured contaminants in this pond water were below detection limits.

The annual concentrations of selected radionuclides from 1992 through 1997 in West Lake water are shown in Figure 4.2.17. Median radionuclide concentrations in West Lake during 1997 were similar to those observed in the past. The gross alpha and gross beta concentrations in West Lake water are believed to result from high concentrations of naturally occurring uranium in the surrounding soils (BNWL-1979, PNL-7662). Annual median total uranium concentrations have remained stable over the last 6 years but the range in concentrations is large. The highest concentrations measured in 1997 were in summer and fall when the water level in the pond was low. It is thought that the relatively large concentration of suspended sediment in the samples is causing the elevated results. Similar total uranium concentrations were reported in PNNL-7662 for West Lake samples that contained high concentrations of suspended sediment. Declines in groundwater levels beneath the 200 Areas have been recorded since the decommissioning of U Pond in 1984 and the shutdown of production facilities (see Section 6.1, "Hanford Groundwater Monitoring Project"). As a result, the water level in West Lake has dropped. Median concentrations of tritium, strontium-90, and technetium-99 in West Lake in 1997 were 1.6%, 49%, and 0.52%, respectively, of the ambient surface-water quality criteria levels (WAC 246-290) and reflected local groundwater concentrations. The concentrations of all other measured radionuclides were rarely above detection limits, except for naturally occurring potassium-40.

4.2.5 Offsite Water

During 1997, water samples were collected from an irrigation canal across the Columbia River and downstream from the Hanford Site that receives water pumped from the Columbia River. As a result of public concern about the potential for Hanford-associated contaminants in offsite water, sampling was conducted to document the levels of radionuclides in water used by the public. Consumption of vegetation irrigated with Columbia River water downstream of the site has been identified as one of the primary pathways contributing to the potential dose to the hypothetical maximally exposed individual and any other member of the public (see Section 5.0, "Potential Radiological Doses from 1997 Hanford Operations").

4.2.5.1 Collection, Analysis, and Results for Irrigation Canal Water

Water in the Riverview irrigation canal was sampled three times in 1997 during the irrigation season. Unfiltered samples of the canal water were analyzed for gross alpha, gross beta, gamma emitters, tritium, strontium-90, and uranium-234,235,238. Results are presented in PNNL-11796. In 1997, radionuclide concentrations measured in this canal's water were at the same levels observed in the Columbia River. All radionuclide concentrations were below the DOE derived concentration guides and ambient surface-water quality criteria levels (DOE Order 5400.5, WAC 246-290). The concentrations of strontium-90 in the irrigation water during 1997 ranged from 0.052 ± 0.031 to 0.080 ± 0.042 pCi/L and were similar to those reported for the Columbia River at Priest Rapids Dam and the Richland Pumphouse (see Section 4.2.1, "Columbia River Water").

4.2.5.2 Pacific Northwest National Laboratory and Washington State Department of Health Survey of Contaminants in the Near-Shore Environment at the 100-N Area

In September 1997, Pacific Northwest National Laboratory and the Washington State Department of Health cooperated in a special study of the 100-N Area near-shore springs. Environmental samples were collected to study radiological and chemical contaminants, with each entity analyzing a portion of the samples. Near-shore samples of water, river sediment, a riverbank spring, periphyton, milfoil, flying insects, clams, fish, and reed canary grass were collected. Results of this study are scheduled to be published in a joint Pacific Northwest National Laboratory/Washington State Department of Health report sometime in 1998. The results for the samples analyzed by Pacific Northwest National Laboratory are given in PNNL-11796.

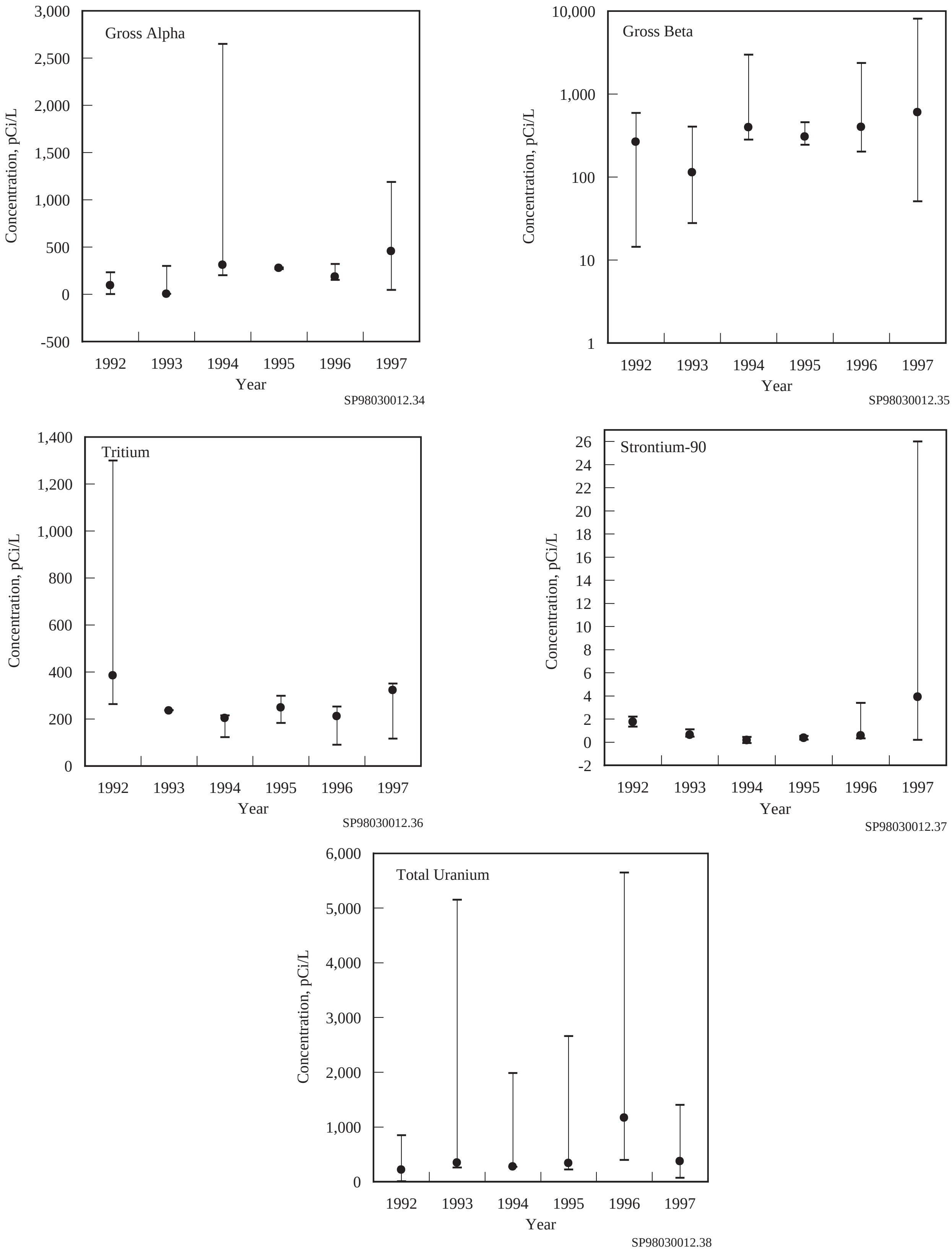

Figure 4.2.17. Minimum, Median, and Maximum Concentrations of Selected Radionuclides in West Lake Water, 1992 Through 1997